THE SCHOOL FOR FIELD STUDIES

Directed Research
SFS 4910

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This syllabus may develop or change over time based on local conditions, learning opportunities, and faculty expertise.
Course content may vary from semester to semester.

Course Overview

The aim of this course is to provide students with the opportunity to apply ecological, biological, and/or social-scientific methods to a field research project that addresses a local issue related to the environment. We will investigate the ways that various methods and theories distinguish (or do not) fact from interpretation, cause from correlation, and advocacy from objectivity. The Directed Research topics are driven by the needs and interests of Bocas del Toro. Through the directed research projects, students will contribute to a growing body of scientific research that informs local conservation and resource management decisions.

Each student will join a faculty-led team that will carry out field research, data analysis, and communication of results in one or across several of the following disciplines: ecology, natural resource management and social sciences. All Directed Research projects are collaborative. The course is designed to build on the information students have learned in the Tropical Coastal Ecology, Principals of Resource Management, and Environmental and Socio-economic Values courses as well as Culture and Language, Directed Research lectures and workshops specifically designed to assist students in understanding the scientific process, testing hypotheses and presenting results in both written and spoken formats.

The research projects and topics being conducted this semester will be provided mid-semester.

TIBS Research Direction

The global research question that we want to address during this research course is:

"How can the natural resources of the BDT archipelago best be managed in order to promote conservation and sustainable use considering the socio economic environment?"

DR Projects

Please be aware that the following DR topics are from the previous semester and may change in future terms based on local conditions, research permits, learning opportunities, and faculty expertise.

1. **Sustaining Indigenous tourism in Bocas del Toro, Panama: a comparative approach to assessing best practices in the archipelago.**
   Instructor: Dr. Leon Mach

Abstract

The goal of this DR project is to explore the intersection between Indigenous peoples, migration, protected areas and tourism in Bocas del Toro (BDT), Panama. We will explore this topic through interviews with members of at least three Ngöbe settlements (Bahia Honda, Salt Creek, Popa II) in the archipelago attempting to offer tourism services to guests. We will also interview tourism providers in BDT to gather their experiences with, and perspectives on these Indigenous run tourism activities. Through collecting this data, we will learn a great deal about how tourism impacts community development within communities and how tourism influences relationships between communities in the archipelago. Through comparing community experience with tourism development, tourism program aid, and protected area creation, our findings may be able to isolate best practices for future sustainable Indigenous tourism (SIT) programs and lead to recommendations for how to improve SIT programs operating locally (most of which receive very low visitation at present).

Intro

Many conservation organizations and governments place heavy emphasis on sustainable Indigenous tourism (SIT) as a mechanism for incentivizing participation in conservation through a non-extractive livelihood option. Indigenous peoples have in many instances, however, experienced tourism as a "rapacious force, commodifying their cultures, placing them in zoolike conditions and damaging sacred sites and precious environments" (Higgins-Desbiolles, 2009, p. 145). In Panama's Bocas del Toro (BDT) province, tourism drives land dispossession for Indigenous communities (Spalding, 2013; Thampy, 2014), but is also a reason many repopulated the archipelago after a long history of being forced off the islands. This study will analyze tourism's role in geographically defining and developing communities (at least: Salt Creek, Popa II, and Bahia Honda) who re-populated the archipelago in the mid-1900s after a long history of their ancestors being forced off the archipelago. These communities were impacted differently by the creation of a protected area in 1988 and received varying degrees of external funding, support, and encouragement to begin Indigenous tourism enterprises thereafter. After years of struggle to market cultural and ecological tourism visitation in each individual community, in 2015, they were encouraged to begin an alliance of Indigenous tourism operators.

This study will present an exploratory case into Ngöbe experiences with tourism development in BDT, a group found to be socially marginalized, economically disadvantaged, and absent in the political process (Guerrón-Montero, 2005; Thampy, 2014; Spalding, 2013). The Ngöbe are the largest Indigenous group in the Republic of Panama and the second largest in all of Central America (Gjording, 1991). To heed calls for more effectively incorporating and privileging Indigenous voices (Carr, Ruhanen, & Whitford, 2016; Higgins-Desbiolles, 2009), we will interpret local perspectives to inform tourism management plans. Our goal is to collaborate with families who repopulated areas now known as Salt Creek, Popa II, and Bahia Honda. Much of the land these families occupied was later zoned as part of the BINMP in 1988 with no dialogue (Guerrón-Montero, 2005). Subsequently, community members in each community received varying degrees of financial support and consultations to begin Indigenous tourism enterprises. Indigenous families were trained to accept guests, display their culture, and educate tourists about the local environment, while preserving surrounding ecosystems as spaces to offer trail hikes and nature tours. Tourist demand, however, has only significantly materialized for bat cave tours in Bahia Honda within the park, which were not planned and are currently being provided in an ad hoc manner. We hope our findings can lead to direct policy recommendations with implications for other SIT initiatives.

Historical Context

The Ngöbe share a lineage of colonization and dispossession. Archaeological and ethnohistoric data from the time of initial European contact (1502-1503) suggest that the archipelago was inhabited by small communities who were socially complex and traded extensively with other Meso-American societies (Cooke, 1997). The Spanish conquest of Central America in the 16th century diminished the Ngöbe population by 99% and forced survivors to retreat from the archipelago to the seclusion of forested mountainous regions on the mainland (Cooke, 1997). The combined threats of disease and slave hunting raids (for sale to British colonists in Jamaica) facilitated another migration from Indigenous coastal settlements in the 19th century (Gordon, 1982).

In the 1950s and 1960s, the Ngöbe population grew rapidly on the mainland, which strained their ability to survive using their traditional swidden agricultural practices and forest modifications, which required low density habitation (Gordon, 1982). Nuclear families lived in houses grouped together in small caseríos with close relatives (Gjording, 1991; Gordon, 1982). Kin networks were formed to hedge against

risky subsistence production in the wet tropics and households relied on borrowing food from extended family members in different climate zones (Gjording, 1991; Gordon, 1982).

Following the collapse of the Banana industry that dominated BDT from the late 1800s until the 1920s, BDT was rendered an economic backwater. Ngöbe returned from the upland river valleys to settle on vacated land. They participated in turtle, lobster and other fisheries for export and also charcoal production from mangrove resources with dramatic ecological consequences (Gordon, 1982; Mou Sue, 1993). Disillusionment with the process of obtaining a *comarca* (demarcating land for autonomous Indigenous governance), promised since the 1940s but not formally declared until 1997 (with roughly half of the land requested), also contributed to Ngöbe seeking land elsewhere (Gjording, 1991). Ngöbe now living in poverty outside of the mainland *Comarca* on untitled land and those living inside protected areas (PAs) are particularly vulnerable (World Bank, 2010). The process of obtaining status as an annex area of the *Comarca* has also been inadequate for many communities in the archipelago for failing to recognize territory used for subsistence (World Bank, 2010).

Protected area and tourism phases of development

Panama's national government initiated a campaign to preserve ecosystems and attract tourism investment in the late 1980s. The General Environmental Law of 1988 gave the National Environmental Authority (now Miambiente) the authority to administer the country's National System of PAs (SINAP) (Spalding, et. al., 2015). As part of this initiative, 13,360 hectares (11,730 marine and 1,630 terrestrial) (Guerrón-Montero, 2005) were set aside for the BIMNP. A conglomerate of international conservation organizations proposed the location as a particularly sensitive/representative sample of the marine and coastal ecosystem (Guerrón-Montero, 2005; Mou Sue, 1993). The park was developed under a "species-specific approach" with special attention given to protecting marine turtles (Mou Sue, 1993, p. 163).

The formation of the BINMP was tied to the federal government's desire to strategically brand BDT as a 'high priority tourism development area' (Guerrón-Montero, 2005). In preparing for the United States to turn over the Panama Canal to Panamanian authorities in 1999, the government implemented plans and policies to diversify the economy through tourism. In 1999 as well, the tourism authority began holding training seminars for Indigenous communities and other stakeholders throughout the country – educating them about the tourism industry, its importance to the nation, and how they might participate (IPAT, 1999). Beginning in 1994, incentives for foreign migrants and developers included reduced taxes on imports, tax exemptions, and immigration benefits, though land ownership had not yet been effective institutionalized (Spalding, et al., 2015). In 2009, the National Assembly passed Law 80 to allow those occupying lands in the coastal zone to obtain titles. Conflicts over land remain commonplace in BDT. Spalding, et al., (2015: p. 163) suggest land conflicts "have resulted in significant change in land use and land tenure over time, whereby foreign investors and Panamanian elites drive price up, limit possibilities of ownership by local communities, and effectively change coastal landscapes and ecosystems."

Roughly 2.3 million visitors enter Panama each year, travel and tourism represents 16.2% of GDP, and leisure tourism comprises more the 70% of tourism (WTTC, 2017). The economic impact of tourism in BDT greatly exceeds the national average (Klytchnikova & Dorosh, 2013). While tourism entry statistics are not kept in BDT, one study reported 100,000 tourists visited BDT's 105 hotel establishments in 2008 – mostly motivated by the desire to relax on the beaches and view abundant wildlife (Solimar International, 2009).

The BINMP is now the second most visited protected area in Panama and is one of the most important attractions on the archipelago. Most tourists (roughly 20,000 in 2016) visit a protected island called Zapatillas Dos to have picnics, snorkel, and relax on the beach. The island is the only area actively patrolled by a rotation of the seven park rangers. Within the terrestrial limits of the park, roughly 400 tourists per month – an increase from the 600 per year reported in 2015 (Spalding, Suman, & Mellado, 2015) – are taking boats up a creek, crossing Indigenous land to enter the BINMP, and hiking a trail to enter a bat cave.

The Panamanian government put forth a ten-year development/management plan for green tourism in PAs (Miambiente, et al., 2016). Two top tier priorities are to enhance cultural/rural tourism products through CBT and to increase opportunities for adventure tourism within PAs.

Literature Review

Sustainable Indigenous tourism

Indigenous people "usually have shared experiences of being colonized, often being removed forcibly from their lands and denied access to natural, historical and cultural resources that can sustain their livelihoods via activities such as tourism" (Carr, et al., 2016, p. 1069). Indigenous tourism studies have often been:

> underpinned by principles of sustainability and thus often espoused development that not only facilitates the economic well-being of Indigenous peoples and ensures conservation of Indigenous cultural landscapes and the environment, but also (and above all), ensures tourism development is used as a positive opportunity for enhancing the social, cultural and place identity of Indigenous peoples (Carr, et al., 2016, p. 1068).

Indigenous tourism involves the four Hs: "the geographic setting (habitat), the ethnographic traditions (heritage), the effects of acculturation (history), and the marketable handicrafts" (Smith, 1996: p. 287). A thread linking many SIT studies is the idea of local control over the process and practice of tourism. De Burlo (2000, p. 304) defines Indigenous tourism whereby, "the native groups are in control of the enterprises which have indigenous culture as the main attraction." The theoretical outcome of local control is that it ought to lead to cultural preservation via the promise of its economic value as a tourism product.

Indigenous ethnicity as a tourism product however, is socially constructed and represents a balancing act for communities to juggle desires to represent themselves as they wish to be seen with global market demands (Camaroff & Comaroff, 2009). Critiques are concerned with how tourism demand for particularly Western framed encounters can reshape the ways communities represent and view themselves to meet tourist expectations (Pereiro, 2016; West & Carrier, Ecotourism and Authenticity: Getting away from it all?, 2004). Tourism has been found to reaffirm the creation and perpetuation of stereotyped images of Indigenous villages, rather than convey local control (Ryan & Aicken, 2005).

Tourism is consistently proposed as one of the only promising economic opportunities for remote Indigenous communities, but demand for SIT is often overstated (Stronza & Gordillo, 2008; Ruhanen, Whitford, & McLennan, 2015). Pereiro (2016), suggests that while some Indigenous tourism enterprises can strip communities of their autonomy and resources, tourism also has potential to lead to cultural revitalization and identity affirmation projects. Most contexts embody varying degrees of each of these poles. Fletcher et al., (2016, p. 1117) proposed four critical considerations as 'crucial prerequisites for sustainable Indigenous tourism development: (1) land title; (2) land management agreements; (3) governance arrangements and (4) policy context.'

SIT and protected areas

Global environmental organizations often endorse mitigating species collapse through conserving "biodiversity hotspots" that can protect the most species per dollar invested (Myers, et al., 2000: p. 853). The main companion policy/management tool has been PAs, which either remove human settlements or greatly restrict resource use options. Exclusionary, top down models remains the dominant ideal. Establishing parks as refuges from the "human predilection to destroy the environment" allowing only transitory tourism experiences that link visitors with nature (Shultis & Heffner, 2016, p. 1227).

These hotspots are almost completely found in low and middle-income countries (LMICs) and are overwhelmingly (as much as 80%) populated by Indigenous communities (Chernela, 2011). Exposure of injustices related to displacement have led to an ideological shift informed by CBT and socio-environmental justice, which "suggests that conservation should provide surrounding Indigenous communities with, at minimum, significant economic and social benefits and, optimally, increased ownership and meaningful involvement in protected area management" (Shultis & Heffner, 2016, p. 1228). Conservation institutions now suggest local buy-in is essential to manage PAs and that Indigenous communities ought to benefit from natural resources through tourism, which incentivizes participation in conservation (Brockington, Duffy, & Igoe, 2008; Eagles & McCool, 2002).

Peters and Higgens-Desbiolles (2012) suggest tourism's capitalist rationality runs counter to the shared, community-based ideals of many Indigenous cultures. Protected area co-management, is exposed as a practice where Indigenous communities are trained to manage their affairs in a particular manner that corroborates and perpetuates dominant discourses related to a bipolar understanding of space (Shultis & Heffner, 2016; Stevens, 2014). Bifurcating places for leisure, preservation, and wilderness from those for work, dwelling and production.

Many studies on CBT and PA tourism also criticize the ways in which Indigenous communities are often viewed as homogenous and fail to consider the existing political realities and divisions within these communities (Brockington, Duffy, & Igoe, 2008). Brockington (2004) suggests, political alliances for conservation are often found in the divisions and diversity within communities in and surrounding PAs. Those adopting particular ideas and practices encouraged by powerful organizations are likely to be supported and strengthened, further marginalizing segments of Indigenous communities.

Considering the multifaceted economic, social, and political linkages between local communities and PAs and the potential positive and negative outcomes associated with park-based tourism, scholars have offered normative best practice prescriptions. Eagles and McCool (2002) stress preparing for park-based tourism in a way that is inclusive of all potential interests affected, is adaptive to changing environments and consumer demands, and has built-in mechanisms to increase social capital through long-term commitment to capacity building, education and technical assistance.

Research Questions

- What is the SIT landscape in the archipelago? What services are being offered by whom and what is the relative success.
- How does tourism impact community development in each community?
- How does tourism influence how communities define themselves and how they view one another?

- Are communities competing for tourism resources and articulating differences (i.e. Salt Creek and Popa) or do they feel they are cooperating for desired collective outcomes (improvement of living conditions in indigenous communities).
- How do tourism providers view SIT offerings? How often do they utilize SIT services? If they do not use these Indigenous tourism providers, why don't they? How do they feel communities could improve their offerings to support higher volume of visitation?

Proposed Methods

We would likely conduct a stakeholder analysis that involves interviewing SIT providers and experiencing SIT operated tours (auto ethnographic). We would also collect semi-structured interviews with tourism providers and potentially survey tourists. We will consider the following:

- SIT providers:
  -How do they benefit from tourism?
  -How do they interpret the challenges with tourism delivery and what changes do they want to see?
  -What components or attributes present appear correlated with success?

- Tourism providers:
  -Perceptions and knowledge of Indigenous tourism opportunities
  -Do they promote and support Indigenous tourism operators (why or why not)?
  -What changes would they suggest might improve SIT performance and demand locally?

- Tourists?
  -Potential visitors?
  -Actual visitors to SIT initiatives?

Proposed Outcomes

The TIBS strategic plan calls for a better understanding of the Human dimensions (Section III, subsections C) and the Policy Context and Environmental Governance (subsection D) that characterize the BDT archipelago. This study will advance this mission by encouraging student to go out into the field and gather narratives from actors involved in delivering and supporting sustainable indigenous tourism on the archipelago. This research can help TIBS to learn information that could help us to advise and support underutilized SIT initiatives in the archipelago. This knowledge could have a direct impact on the lives of indigenous stakeholders and could help further incentivize conservation practices if tourism initiatives are improved in a way that facilitates more direct economic benefits from community conservation.

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2. The hidden bio-terrestrial world behind Starfish Beach: A biodiversity assessment of mangrove forests at Starfish Beach, Isla Colon, Bocas del Toro.

Instructor: Leonor Ceballos, M.S.

Overview

The diversity and abundance of terrestrial organisms and habitats in Bocas del Toro (BDT) supports an economy that is dependent upon the health of the ecosystem and the continued perception of Bocas as an Island Paradise. Currently, Bocas is considered to be the number one destination in Panama both for touristic and retirement purposes. Uncontrolled development has impacted the health of the BDT ecosystem and it is now in a state of ecological distress. Tourism began in earnest towards the end of the 1900s. Prior to 2001 there were not even tour guidebooks for Panama; however, tourism is now the main economy of Bocas bringing over two million visitors per year.

One of the top ten tourist destinations in Panama is a beach famous for its white sand and the thousands of sea stars that once gathered there. Visitors and locals call the beach, Play Estrella or Starfish Beach. Bocas is one of Panama's main tourist attractions with an estimated 225,000 visitors per year and an 8% annual rate of growth in tourism. In 1996, there were no tourists, no restaurants, and no souvenir shops at Starfish Beach. Around 2003 and 2004, the tourism industry began to take advantage of the beach through marketing and tours. One restaurant opened along the waterfront, and shortly after another and another, and now the area is full of businesses and visitors (Scott, 2017).
Almost imperceptible for tourists visiting Starfish Beach, stands an area of white mangrove forests spread on the background of the white sand beach. This mangrove forest hides an interesting story. On April 22, 1991, a large earthquake (M_w = 7.7) occurred along the Caribbean coast of Costa Rica and western Panama. Uplift of the Caribbean coast ranging from 1.5 m near Puerto Limón and decreasing gradually toward the southeast was observed along the Caribbean (Suarez et al., 1995). As a result, the waterfront uplift at 1.85 m (6 ft. 1 in) in Bocas. At the Starfish Beach area, land went down half a meter, allowing seawater to intrude the coast and to create the particular habitat needed for the mangroves to grow and establish. White mangrove seeds (*Laguncularia racemosa*) floating in the ocean found the appropriate environment and were noticed in the region by 1996. The establishment of this mangrove forest created a unique ecological environment that hosts rich assemblages of species. A number of crabs, insects, spiders, reptiles, birds and mammals live among the roots, on the trunks or even forage in the canopy, thriving in the habitat and contributing to its unique character.

This project aims to unveil the currently unexplored diversity of life hidden behind the fairly new mangrove forest in the Starfish Beach area. Additionally, and in conjunction with the TCE Fall 2018 DR aims, this project seeks to determine anthropogenic impacts on mangrove ecosystems in a heavily touristed site. The mangrove forest in the Starfish Beach area was stablished as a result of the 1991 earthquake, making this white mangrove forest relatively new to the area and offering the opportunity to explore the establishment of a new environment for multitude of species. In particular, using bio-indicator taxa, the project seeks to assess the habitat suitability in mangrove forest within the boundaries of the Starfish Beach area, to create a baseline for a diagnosis of what is there now, how it is changing with time, how it is impacted by human use, and potentially, to compare the forest to those mangrove forest areas of older establishment, and those under direct threat form anthropogenic forces leading to forest degradation. The current project seeks to conduct an intense biodiversity survey at Starfish Beach.

Main Research Question:

“What is the biodiversity of the mangrove forests at Starfish beach in Bocas del Toro?”

Questions that can be addressed in this research project are:

- What indices can be used to assess the impacts of tourism on the biodiversity and species richness of the mangrove forests at Starfish Beach?
- How have different practices of tourism at Starfish Beach modified the mangrove forest and/or affected the biodiversity in the land they occupy?
- How are tourism managing practices impacting the natural resources of the mangrove forest at Starfish Beach?
- What is the biodiversity status in habitat modified for tourism practices at Starfish Beach?
- How is the status of bio-indicator populations within the mangrove environments; specifically environments which are suitable for promoting biodiversity?
- Which environmental variables at different sites are associated with greater species richness?
- What is the biodiversity status of mangrove forests inside the areas used for tourism practices at Starfish Beach?
- Is there a differential or interaction effect of the tourisms practices on mangrove forests with diverse levels of modification?
- Is the mangrove forest at Starfish Beach and habitat suitable to support viable populations of organisms common to mangrove forests?
- How has the mangrove forest habitat suitability been affected by tourism practices at Starfish Beach?

Methodology

Habitat suitability is defined as the ability of a habitat to support a viable population over an ecological time-scale. Habitats are normally evaluated by relating changes in habitat features to changes in species density, richness, and diversity (Kellner et al. 1992). This project will assess habitat suitability using different taxa as bio-indicators. Bio indicators are organisms of species highly sensitive to the changes in the surroundings, which can provide information about the health of the ecosystem. By sampling and studying population dynamics of such organisms, it is possible to monitor ecological changes and reveal positive and negative effects of human activities in the area. Species are identified as bio indicators when their abundance and population fluctuation clearly vary in response to any environmental change in a particular habitat (Mouillot et al., 2002). Changes in the population levels, physiological processes and behavioral modifications of such organisms are used to detect changes in the environmental health. This project will assess habitat suitability using bio-indicators that had been identified as relevant to the mangrove forests. Groups of organisms will be selected in order of their importance as indicators of environmental quality and habitat suitability.

Diverse methodology will be conducted according to the bio -indicator to be evaluated:

- Mollusks: mangrove snails (*Littoraria angulifera)* are found on mangrove prop roots, leaves, and branches from the waterline up to 7 meters above the high tide line, mangrove snails are bio indicators of mangrove health. Along with mangrove crabs are the most distinctive animals associated with the upper prop roots of Red Mangrove. They play an important role in controlling the structure of intertidal communities. Mobile intertidal animals, such as periwinkles, can respond to differences in microhabitats along a vertical gradient and change their behavior in response to different environmental conditions. Evaluating their

- Ants, beetles, spiders, and other land arthropods: invertebrates play an important role in shaping the structure and function of terrestrial ecosystems, such as mangrove forests. Arthropod populations will be identified and quantified in order to reveal the habitat suitability. Different methods will be conducted according to the group of invertebrates.

- Crabs: crabs in mangrove communities play an important role in shaping the structure and function of mangrove forests. Additionally, fiddler crabs can have a significant effect on plant production and substrate characteristics. A variety if methods will be conducted to identified crab populations and its effect on mangrove communities.

- Reptiles: widespread searches will be conducted, walking and reviewing the area, under the leaf litter, under the trunks and stones, in cavities, and any place considered appropriate. For each search the duration time, the category of the habitat where the sampling is being performed and the number of observed specimens will be recorded. Photographs will be taken, in order to identify the species observed.

- Birds: birds will be visually observed using binoculars. The number of observed birds will be recorded, along with the calls listened during the surveys. Additionally, bird calls could be recorded for further identification. Ornithological guides will be used to identify the individuals observed *in situ*, and photographs will be taken for further identification. Furthermore, nesting sites will be searched for and identified within the mangrove forests.

- Mammals: camera traps will be used to sample for mammals, they will be placed on specific areas of the studied sites; camera traps could be baited. Cameras will be removed no longer than two weeks after being placed on sites. Pictures taken with the cameras will be analyzed for identification of mammal species and will be used to compare mammal abundance and diversity between sites. In addition, 25 m^2 quadrats will be sampled for fecal matter, footprints and fur and, when possible, collected for further identification. Samples collected will be used in determining mammal diversity between sites. Any mammal sighted or heard along the sampling period will also be recorded.

In addition, other variables will be tested as follow:

- Forest structure: the occurrence, abundance and diameter of all trees ≥10 cm diameter at breast height (DBH) will be recorded in 10x10 m quadrants. During sampling, vegetative samples (leaves) or reproductive (flowers and or seeds), and photos of each different species will be taken for further identification. Abundance and diversity of tree species will be used to assess the structure of the forest at each site.
- Litter fall and decomposition: in 10x10 quadrats, litter bag experiments will be used to follow changes in mass and chemical constituents during decomposition of leaves; providing an understanding of the decomposition speed in the area, and its relationship with environmental quality.

- Carbon sequestration: mangroves are among the most carbon-rich forests in the tropics. Above ground carbon sequestration will be calculated by linear transects laid parallel to each other, spaced approximately 5-7m apart from one another. For each transect survey, every live tree trunk along the 20x1m transect will be measured for diameter approximately 3.5 feet above the ground, using a Diameter-at-Breast-Height (DBH) tape. For every transect sample, the trunk biomass results were totaled and added to the total root biomass, then divided by twenty meters to determine an average kgC/m2 measurement. The average of all samples was then taken to determine an overall aboveground

biomass average. The overall aboveground carbon storage average could be compared to past studies to estimate potential soil carbon storage across all sites surveyed.

Significance to the TIBS Strategic Research Plan

The above research proposal directly addresses the following projects of the TIBS strategic plan as stated in section III- research components and projects:

A. Component One: Assessing Marine and Terrestrial Environment and Species

Project 1.1. Quantification of effects on biodiversity due to human activity in different land-use systems
Project 1.2. Arthropods as bio-indicators of anthropogenic stress and sustainable forest management, with a focus on different land use systems
Project 1.3. Effects of tropical rainforest modification on arthropod population diversity as measured through leaf litter and top-soil sampling

B. Component Three: Monitoring and Management of Marine and Terrestrial Resources

Project 3.1. Taxonomically diverse inventory on the impacts of tropical forest modification in different landscapes of Bocas del Toro
Project 3.3. Edge effect on species richness and diameter of woody plants in the Archipelago of Bocas del Toro, Panama

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3. Implications of tourism on the biomass, abundance and behavior of *Oreaster reticulatus* at Starfish Beach

Instructor: Carolyn Kovacs, MS

Overview

Tourism is a major industry worldwide, with 1,326 million international tourist arrivals in 2017 (World Tourism Organization, 2018). This reflects a 7.0% increase since 2016, and tourism has increased annually in all but one year within the past decade (World Tourism Organization, 2018). While the

reasons for travel vary, many tourists visit locations known for their natural beauty and the fauna found in the area. This leads to an increase in visitors to areas that may otherwise have a low human presence, which in turn may affect both the physical environment and the organisms living there. Increased development may take place in order to provide amenities for people, often resulting in habitat modification and a decreased environmental quality. The presence alone of humans may cause animals to flee, alter their behavior, or experience increased levels of stress, which may in turn affect reproduction or body condition (Pfeiffer and Peter, 2004; Amo et al., 2006). Animals may also choose to avoid an area that would normally be used as habitat in order to avoid humans (Thiel et al., 2008). Additionally, organisms may become exposed to novel or higher intensities of sound than normally encountered as a result of human presence. These sounds and vibrations may confuse animals or interfere with their ability to sense predators or prey (Green and Giese, 2004). This is especially true for marine environments, where sounds can travel further and more rapidly.

The Bocas del Toro Archipelago is a series of islands on the Caribbean coast of Panama, which until the 1990s were only inhabited by a small resident population. However, in the 1990s Bocas del Toro was labeled as a high priority tourism development area by the government, and within the past three decades there has been an increase in both infrastructure and visitors to the island (Suman, 2002; Klytchnikova and Dorosh, 2013). Tourists to the islands typically visit one or more sites for the beautiful beaches, clear waters and to observe marine life. Tour operators tend to frequent many of the same sites, which include Cayo Coral or Hospital Point for snorkeling, Dolphin Bay to view dolphins, and the Zapatillas Islands or Starfish Beach for picturesque beaches. Starfish Beach, known locally as Playa Estrella, also draws visitors who want to see high concentrations of its namesake animal, the starfish, properly known as the cushion sea star, *Oreaster reticulatus*.

O. reticulatus is the largest member of the family Oreasteridae, with a maximum radius of approximately 20 cm (Scheibling, 1980; Guzman and Guevara, 2002). *O. reticulatus* is found in the western Atlantic and throughout the Caribbean in densities of 1 to 14 individuals per 100 m^{-2} (Scheibling, 1980; Guzman and Guevara, 2002). The yellow and orange colored adults are typically found in sandy bottom habitats, whereas green or mottled juveniles are located in nursery habitats comprised of seagrass beds, mangroves, and fringing reefs (Scheibling, 1980; Scheibling and Metaxas, 2010; Guzman and Guevara, 2002). Although *O. reticulatus* can feed on macrofauna via predation, it primarily feeds through microphagous grazing and deposit feeding, consuming organisms such as diatoms, cyanobacteria, meiofaunal crustaceans, and particulate detritus found on the blades of seagrass or within sediment (Scheibling, 1982).

Sea stars may be predated on by fish as juveniles, but they have few natural predators once they reach adulthood. The main predator of adult *O. reticulatus*, the Atlantic triton (*Charonia variegata*), is scarce (Scheibling, 1980). Despite the fact that *O. reticulatus* have few natural threats, they exhibit many life history traits that make them vulnerable to exploitation by humans or habitat modification (Scheibling, 2014). Because they grow slowly, have a delayed sexual maturity, and typically have a long life span, they would not be able to quickly recover from a population decline. Due to their large size and bright orange color as adults, *O. reticulatus* are conspicuous animals that have caught the attention of humans for the curio and souvenir trade for decades (Guzman and Guevara, 2002). With increased tourism, sea stars are also prone to higher levels of disturbance and potential stress when picked up. *O. reticulatus* engages in directional foraging, therefore reducing the chance that it will encounter an area in which it has already fed (Scheibling, 1981). It can also reabsorb body-wall tissue if it is under nutrional stress, resulting in decreased size but preventing death due to starvation (Scheibling, 1980). Therefore, if humans move a sea star, the foraging pattern of the sea star may be disrupted and result in a decreased

body condition. Although there is little scientific information available about the physiological stresses on sea stars from being handled by humans above or below the water or on the effects of chemicals in sunscreens on sea stars, it is expected that these may have negative consequences as well. Sea stars are also threatened by a loss of habitat due to development, particularly the mangroves, seagrass beds, and fringing reefs that juveniles use as a nursery (Scheibling and Metaxas, 2010).

A comprehensive survey of *O. reticulatus* in the Bocas del Toro archipelago in 2000 estimated a population size of 7 million sea stars (Guzman and Guevara, 2002). The average population density was 1.49 individuals per 100 m^{-2}, and while no stars were observed in 47.9% of the archipelago, three sites had high densities of 8-12 individuals per 100 m^{-2}. Sea stars were found primarily in areas of the archipelago that were away from areas of high runoff, which may affect sedimentation and nutrient levels in the water and therefore the available habitat. The population was comprised of a high proportion of juveniles (83%), indicating frequent recruitment (Guzman and Guevara, 2002). The average size at reproductive age (15 cm radius) was also 3cm larger than in other reported areas (Scheibling, 1980), and well-developed gonads were observed throughout the year, as opposed to seasonally. Long periods of warm weather and high rainfall throughout the year may be responsible for year-round reproduction (Guzman and Guevara, 2002). Guzman and Guevara noted that most research in the Caribbean had been focused on the biology of *O. reticulatus* and rather than on their management. The authors warned that in the future, *O. reticulatus* in Bocas del Toro might face threats due to harvesting or a decrease in available habitat due to development, either directly or indirectly from increased runoff.

Since Guzman and Guevara's paper was published in 2002, tourism has increased dramatically in Bocas del Toro. Starfish Beach, located near Boca del Drago on Isla Colón, is an example of this dramatic increase in tourism. Both locals and tourists visit Starfish Beach because it is protected with little wave action, and therefore is safe for swimming. In addition, tourists are drawn to it for the high abundance of sea stars. The number of visitors began to increase over time, and in 2010 the first small restaurant was established on the beach (Dixon, pers. comm.). The popularity of the site continues to grow, and with this growth restaurants are operating with no infrastructure to properly handle restaurant or human waste. As of 2018, there were nine restaurants located at Starfish Beach. The restaurants are required to have health certificates and the waste management has improved, although it is likely that sewage and other waste is entering the nearby waters (Dixon, pers. comm.). There are also more people on the beach and in the water, boats landing on the beach, and music playing through speakers on the beach. According to locals, the number of sea stars in the area decreases when the number of people and the volume and presence of music increases (Dixon, pers. comm.).

It is commonly lamented and repeatedly stated by longtime residents in Bocas del Toro that there used to be more starfish at Starfish Beach, and that their numbers have decreased due to an increase in tourism in the area. However, there has been no scientific study to support these statements. The overall aims of this research are to conduct a population assessment of sea stars at Starfish Beach and the surrounding area and to evaluate the impacts of tourism on the population. These aims will facilitate the development of a collaborative research project, designed to answer the following research questions:

1. What is the population size and biomass of sea stars at Starfish Beach and in nearby non-tourist areas?
2. What threats to sea stars exist at Starfish Beach?
3. Is there a relationship between sea star abundance and environmental (depth/substrate) or

anthropogenic (number of people/restaurants/boats) factors?

4. Do sea stars move throughout the day?
5. What are the feeding patterns of sea stars?
6. Do sea stars move in response to anthropogenic factors such as increased human presence or vibrations from speakers or boat engines?
7. Does moving sea stars from one area to another, or grouping them together, have an effect on their movement or feeding patterns?
8. Where are the juvenile nursery sites for the sea stars at Starfish Beach?
9. In comparison to other heavily touristed sites with an abundance of sea stars, ex. "Hollywood", is the starfish beach population at greater risk due to habitat or human interference?

Methods

The following techniques will be used:

1. Surveys will be conducted using transects according to the methods described in Scheibling and Metaxas, 2010 to determine the abundance of sea stars at Starfish Beach and in the mangrove and seagrass habitats nearby. Information about the individual sea stars, the natural environment, and anthropogenic environment will be included.
    a. Sea stars: coloration, size (radius), and feeding behavior
    b. Natural environment: depth and microhabitat (substrate)
    c. Anthropogenic environment: the number of people, boats, speakers, and restaurants within or in front of the transect

2. Wet weight and biomass estimates will be calculated based on size data using equations determined by Scheibling, 1980.

3. Surveys will be conducted in the morning and afternoon to monitor the movement of sea stars throughout the day, and be compared to the changes in the anthropogenic environment.

4. In situ experiments will be conducted to determine if sea stars move back if they are moved to a different area and if sea stars move in response to music / boat engines / vibration. In addition, experiments will be conducted to determine if being picked up affects feeding rates and movement patterns. Movements will be marked according to the methods described by Scheibling, 1981.

Significance to the TIBS Strategic Research Plan

The above research proposal directly addresses the following components of the TIBS strategic plan:

- 1.1. *Quantification of effects on biodiversity due to human activity in different marine and land-use systems*

Part A - Component One: Assessing Marine and Terrestrial Environments and Species.

Part B - Component Two: The Role of Protected Areas in Conservation and Potential Effects of Anthropogenic Activities on Near Shore Habitats and Communities around Bocas Del Toro.

Part C- Component Three: Monitoring and Management of Marine and Terrestrial Resources in the BDT archipelago.

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Collaborative Course Assessments

Assessment Item	Value (%)	Group (G) or Individual (I)
Literature Review	15	I
Project Proposal	10	G
Peer Review	20	I

Final Paper	25	G
Presentation	15	I
Group Poster	10	G
Directed Research Skills- Data Collection and Management	5	I
TOTAL	**100**	

You will present your DR projects in the standard scientific formats of a peer-review style report and a conference style presentation. You will also be graded on your data management and your positive contribution to the class. Comprehensive details of all assignments will be provided separately.

Project Proposal: The project proposal has two elements: a ***Literature Review*** and a ***Project Summary***.

1. **Literature Review (15%)**

The main objective of the *Literature Review* is for students to familiarize themselves with previous research and publications in the area of their chosen Directed Research project. The literature review should draw upon a large literature base (where possible) to firstly review the current status of research in the field and then to build a setting and justification for research that still remains to be done.

LITERATURE REVIEW: A critical evaluation of knowledge in subject area

JUSTIFY DR PROJECT: Highlight knowledge gaps and give justification of DR project

2. Project Summary

The main objective of the *Project Summary* is for students to develop a detailed outline (framework) for their Directed Research. The DR Project summary must include the following items:

AIMS: A list of questions that the student would like to answer as a result of the research project they will design.

MATERIALS & METHODS: A detailed description of the methods to be used in their study and why these methods will be used over other potential methods. This should include sampling design, as well as the physical data collection methods to be employed.

PREDICTED FINDINGS: A list of 'predicted findings' and implications for each

Peer Review (20%): Each group member will be evaluated by each of their peers and receive the average grade of this evaluation. The grade rubric will assess: effort, professionalism, ability to work in a team atmosphere, academic contribution to the project, and quality of the contribution. Each team member will review themselves and in addition provide assessment on their peers.

Final Report (25%): The final report is written in the style of a peer-review submission to a journal in the appropriate field. You will have ample opportunity for guidance from your DR supervisors throughout the DR period and especially during DR data analysis week. The analytical tools for research workshops in the DR course (and complementary classes in other courses) are designed to prepare you for producing the Results section and improve the quality of your work.

DR Group Poster (10%): Students will be grouped based on their research project topics and will create and present a scientific poster to the community.

Presentation (15%): You will present a subset of your DR work in a conference style presentation of 12 min length with additional time for questions. Unless the scope of your DR project is very small, you should not attempt to squeeze in everything from your final report into this presentation. Making sure that you are within the time limit is a very important skill and so thorough rehearsal is important.

Data Management (5%): It is important to record and store research data in a manner that is useful. You will need to provide an Excel sheet (or sheets) with your research data in a format that is intelligible to someone else. You need to provide both raw and manipulated data you used to create figures, tables and to run statistical tests. You need to annotate your spreadsheets (use text boxes if appropriate) so that an outsider can understand what the data are.

Directed Research Skills: Your Directed Research Skills will be graded throughout the DR course by your supervisor. Your final grade will depend upon your attendance to all DR activities, active involvement and competencies in field data collection, data entry and group participation/support.

Directed Research Community Presentation Video: In addition to your individual and group work, you will present your work to the larger community on Saturday, May 5, 2018. Local stakeholders, government officials, friends of SFS and concerned citizens attend this event. You will create a video presentation, preferably in Spanish or in English with Spanish subtitles using footage that you have recorded during directed research to present to the community. The videos should outline the goal of the research project, its importance to Bocas and to greater society, methods, results, conclusions and future plans.

Formatting of Written Work

Format written assignments using the following guidelines: 1" page margins, 1.5 spaced lines, Times New Roman, 12-pt. font.

Submission of Assessments

To submit work, save the file on the server, in the folder Students>DR>Assessment. Please note that files are time and date stamped, and this information will be used to evaluate if he submission was before the deadline. There will be no discussion as to if these are accurate. All work is expected to be submitted on time, no exceptions.

Grading Scheme

A	95.00 – 100.00%	B+	86.00 – 89.99%	C+	76.00 - 79.99%	D	60.00 - 69.99%
A-	90.00 – 94.99%	B	83.00 – 85.99%	C	73.00 - 75.99%	F	0.00 – 59.99%
		B-	80.00 - 82.99%	C-	70.00 - 72.99%		

Grading Rubrics for Assessments

For assessment, a rubric outlining grading components and the weighting for each will be provided at the time the assignment is set.

Important General Reminders

Plagiarism - Using the ideas and material of others without giving due credit, is utterly against the principles of scientific research and scholarship. In the context of assessment it is considered cheating and will not be tolerated. A grade of zero will be assigned for any assignment, or part thereof, that is adjudged to have been plagiarized. Any student adjudged to have allowed their work to be plagiarized by another student will have punitive measures taken against them. All assignments unless specifically stated should be individual pieces of work.

Deadlines - Deadlines for written and oral assignments are instated for several reasons: they are a part of working life to which students need to become accustomed and promote equity among students. Deadlines allow faculty ample time to review and return assignments before others are due. Deadlines as codified in this syllabus must be strictly adhered to unless there is a specific written amendment.

Participation - Since we offer a program that is likely more intensive than you might be used to at your home institution, missing even one lecture can have a proportionally greater effect on your final grade simply because there is little room to make up for lost time. Participation in all components of the program is mandatory because your actions can significantly affect the experience you and your classmates have while at SFS, Panamá. Therefore, it is important that you are prompt for all land and water based activities, bring the necessary equipment for field exercises and directed research, and simply get involved.

Recording observations - It is highly recommended that students carry and use small notebooks to jot down observations, reflections, and sketches while on FEXs and during personal excursions. Recording media (still images and video) can also be valuable for illustrating reports and presentations. Generally speaking though, you should ask permission of subjects before photographing them (ask the permission of parents before photographing children) and do not post pictures of research informants or subjects on social media sites (we will cover this in more detail during the research ethics class).

Positive contributions- DR Skills and Data Management

You will earn these points by going above and beyond simply meeting the course requirements. For example, you will be expected to turn in raw data in organized tables, participate in discussions, assist your peers, and demonstrate an overall positive attitude.

Course Content

Key: L: Lecture, **FEX**: Field Exercise, **W**: Workshop or structured discussion, **P**: Student Presentation. **LC**: Leonor Ceballos, **CS**: Cinda Scott, **LM**: Leon Mach

Lecture Title and Description	Type	Time (hrs)	*Lecturer*
DR01 Course introduction Review of the DR syllabus and discussion of the course objectives	L	0.5	CS
DR02 Project Descriptions Faculty introduce DR projects	L	1	CK, LC, LM
DR03 DR Meetings Students meet in their respective DR groups with faculty advisors	W	1	ALL DR FACULTY
DR04 Analytical Tools for Research This lecture gives an overview of some of the most common statistical methods and tools to analyze scientific data	L	2	LC, CK, CS
DR05 Ethics in Research Introduce students to the ethical considerations involved in science.	L	1	LM
DR06 Effective Communication Skills I: Figures and Tables Why do we use figures and tables? How should they look? What should be included?	L	1	CK, LC
DR07 Effective Communication Skills II: Presenting data, scientific communication	L	1	ALL DR FACULTY
DR08 How to write and present a scientific poster	L	1	ALL DR FACULTY
DR09 Project Proposal and Final Paper Faculty will discuss the requirements and expectations of all components of their projects with a particular emphasis on the project proposal *Proposals are due Wednesday, April 11, 2018 at 2 pm*	L	1	CK, LC, LM

Lecture Title and Description	Type	Time (hrs)	*Lecturer*
DR10 DR Prep Day I- Method Testing Students work with DR faculty members in the classroom, laboratory and in the field to determine logistics, plan research collection days and practice field methods	FEX	6	ALL DR FACULTY
DR11 DR PREP DAY II/DR FIELDWORK BEGINS Students work with DR faculty members in the classroom, laboratory and in the field to determine logistics, plan research collection days and practice field methods. This day may also be used as a full collection day if methods and logistics are confirmed.	L	8	ALL DR FACULTY
DR12 Field Work (10 days in the field)	FEX	10 days field collection	ALL DR FACULTY
DR13 Data Analysis and write up of final paper (3-4 days) *Papers are due Tuesday, Nov 27, 2018 at 9 am*	W	3-4 days	ALL DR FACULTY
DR14 Preparation time for oral presentation (1-2 days)	W	1-2 days	ALL DR FACULTY
DR 15 Oral Presentations I- Class Presentations *Thursday, Nov 29, 2018* **DR 15 Oral Presentations II-** Community Presentations *Saturday, Dec 1, 2018* Community Posters due by 10am, *Saturday, Dec 1, 2018*	P		ALL DR FACULTY